# Improving STEM Education through the Redesign of the Advanced Placement Science Courses

**Andy Elby,** University of Maryland, AP Physics 1 Development Committee

**Audra Ward,** The Marist School, AP Biology Consultant

**Serena Magrogan,** Director AP Chemistry, The College Board

National Science Foundation
WHERE DISCOVERIES BEGIN

AP® CollegeBoard

# Agenda or Summary Layout


STEM Ed Goals and Challenges

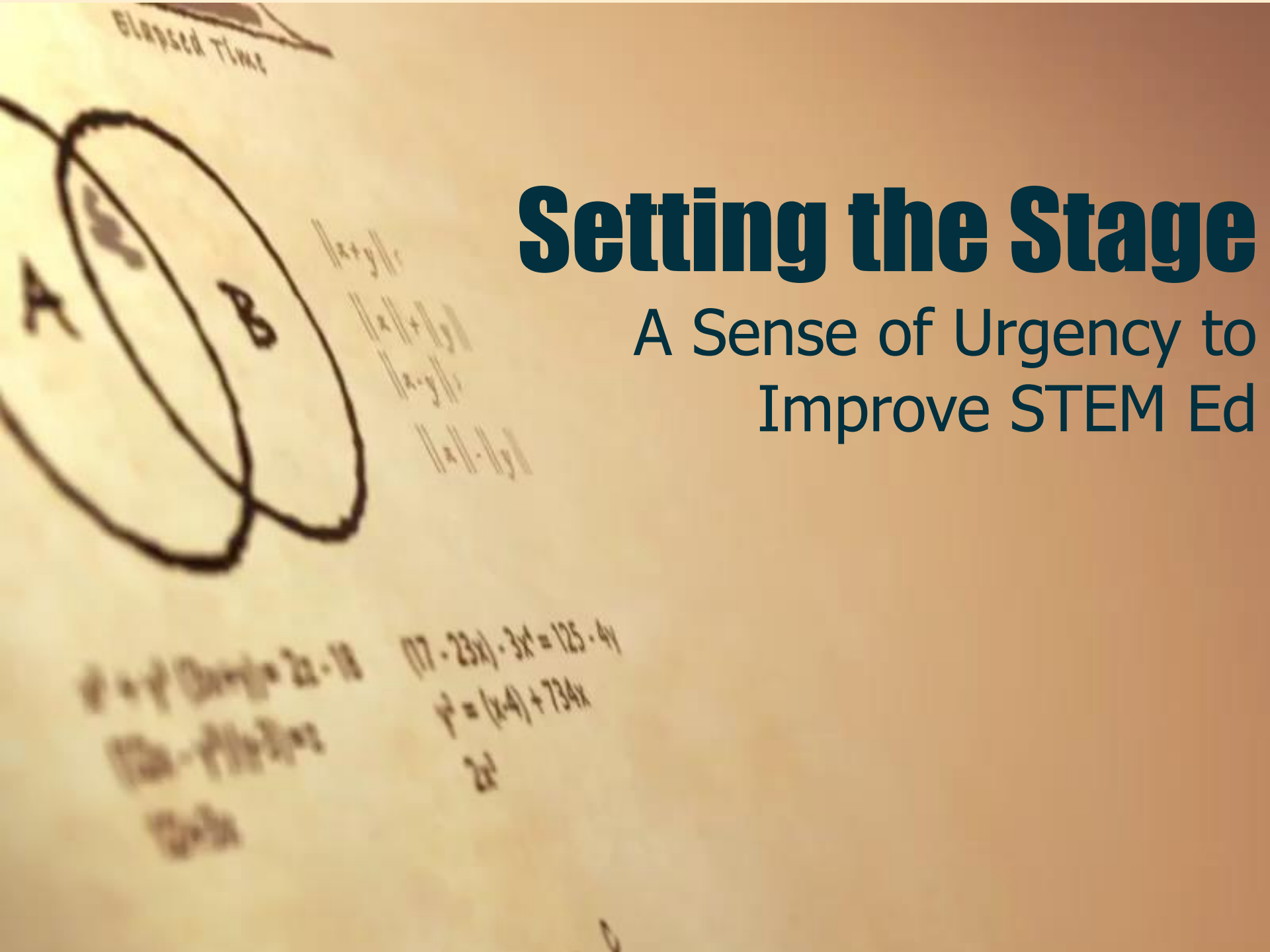
AP Science Curriculum Redesign to Meet STEM Ed Goals

AP Exam Changes to Support STEM Ed Goals

AP Science Instruction Changes to Support STEM Ed Goals

National Science Foundation
WHERE DISCOVERIES BEGIN

AP CollegeBoard



# Setting the Stage

## A Sense of Urgency to Improve STEM Ed

# STEM Ed: Goal

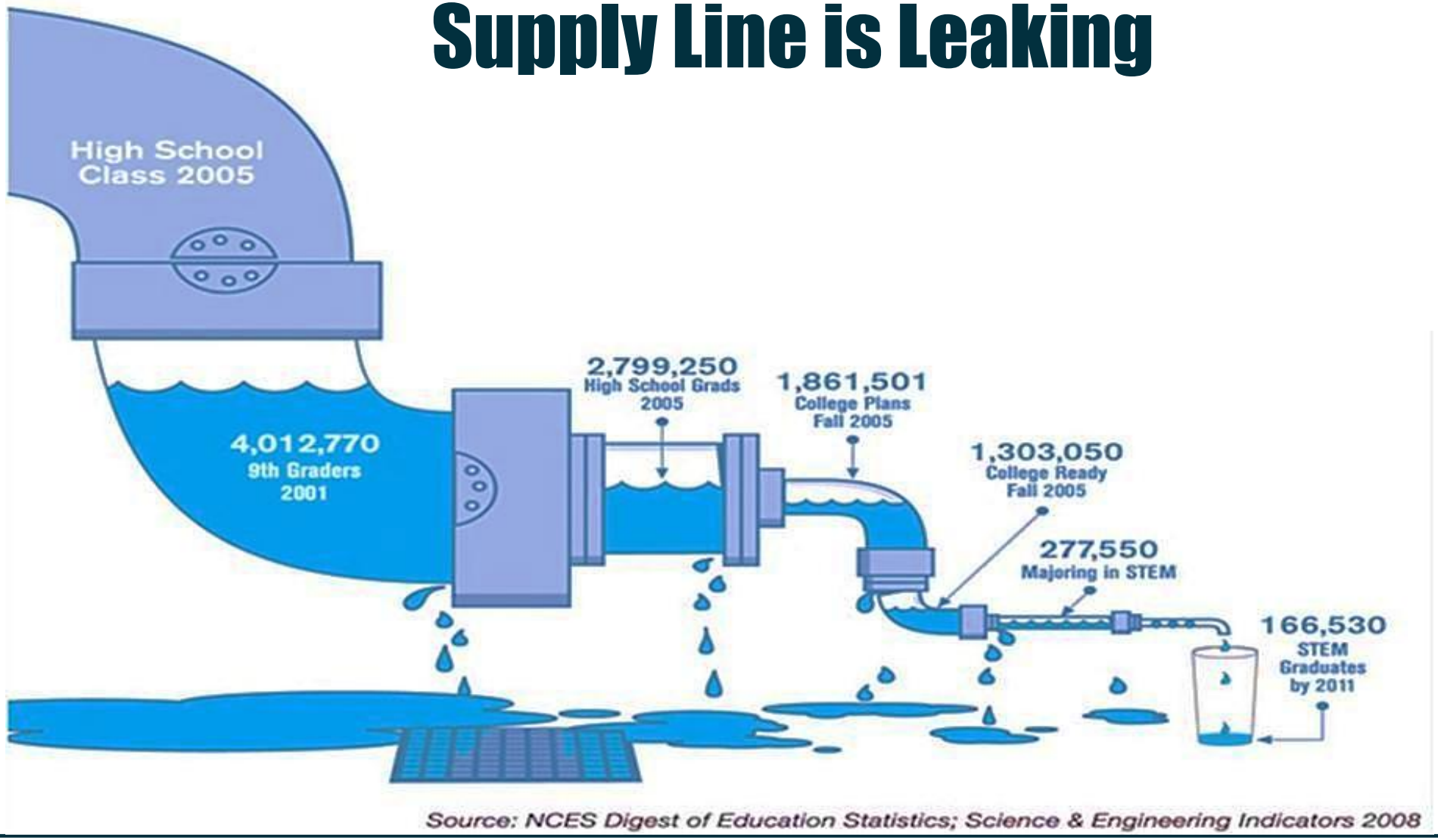
Develop and **supply** the applicants needed for the demand of STEM-capable workers

NRC (2011) *Successful K-12 STEM Education*

National Science Foundation
WHERE DISCOVERIES BEGIN

AP® CollegeBoard

# Supply Line is Leaking

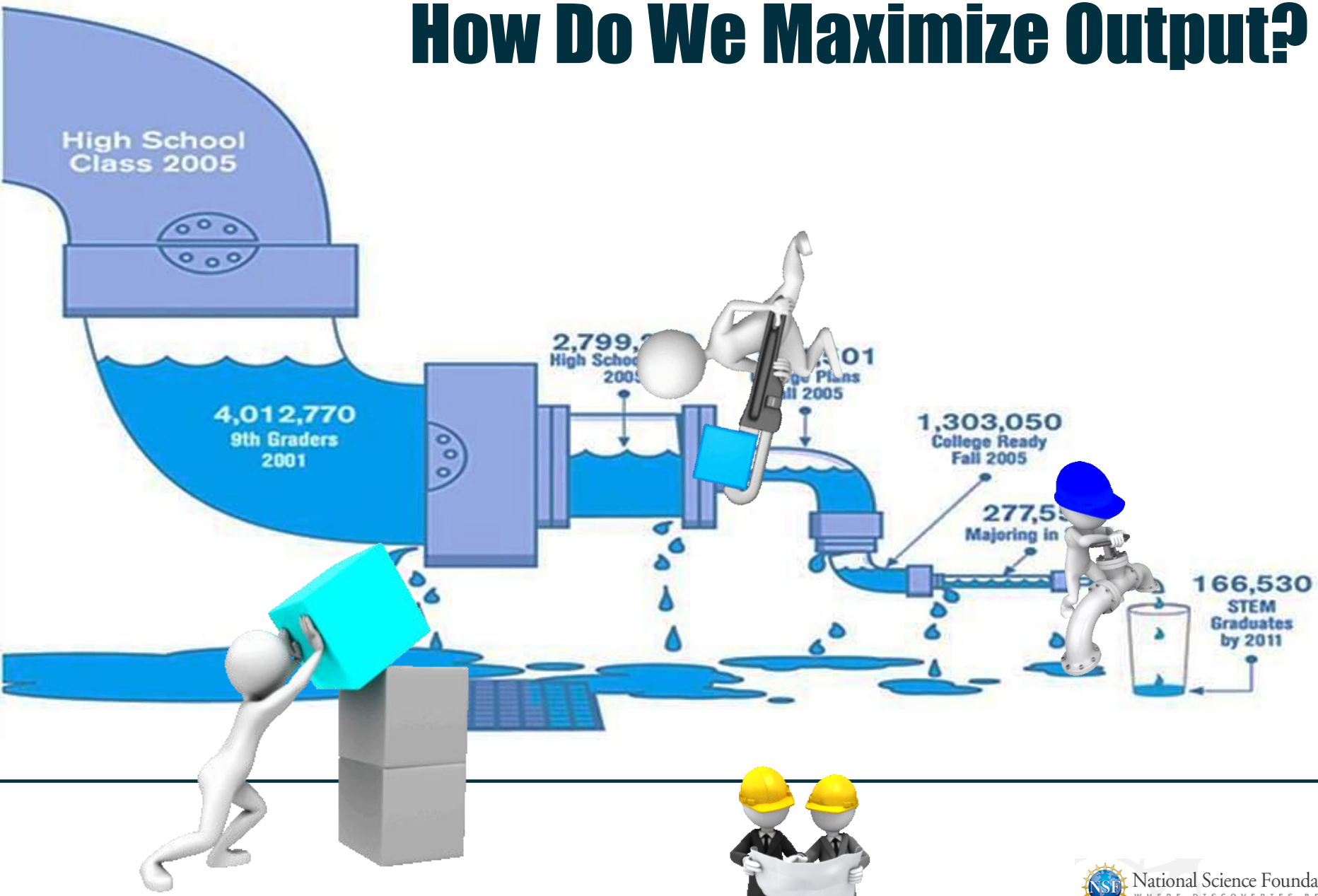



*Source: NCES Digest of Education Statistics; Science & Engineering Indicators 2008*

National Science Foundation
WHERE DISCOVERIES BEGIN

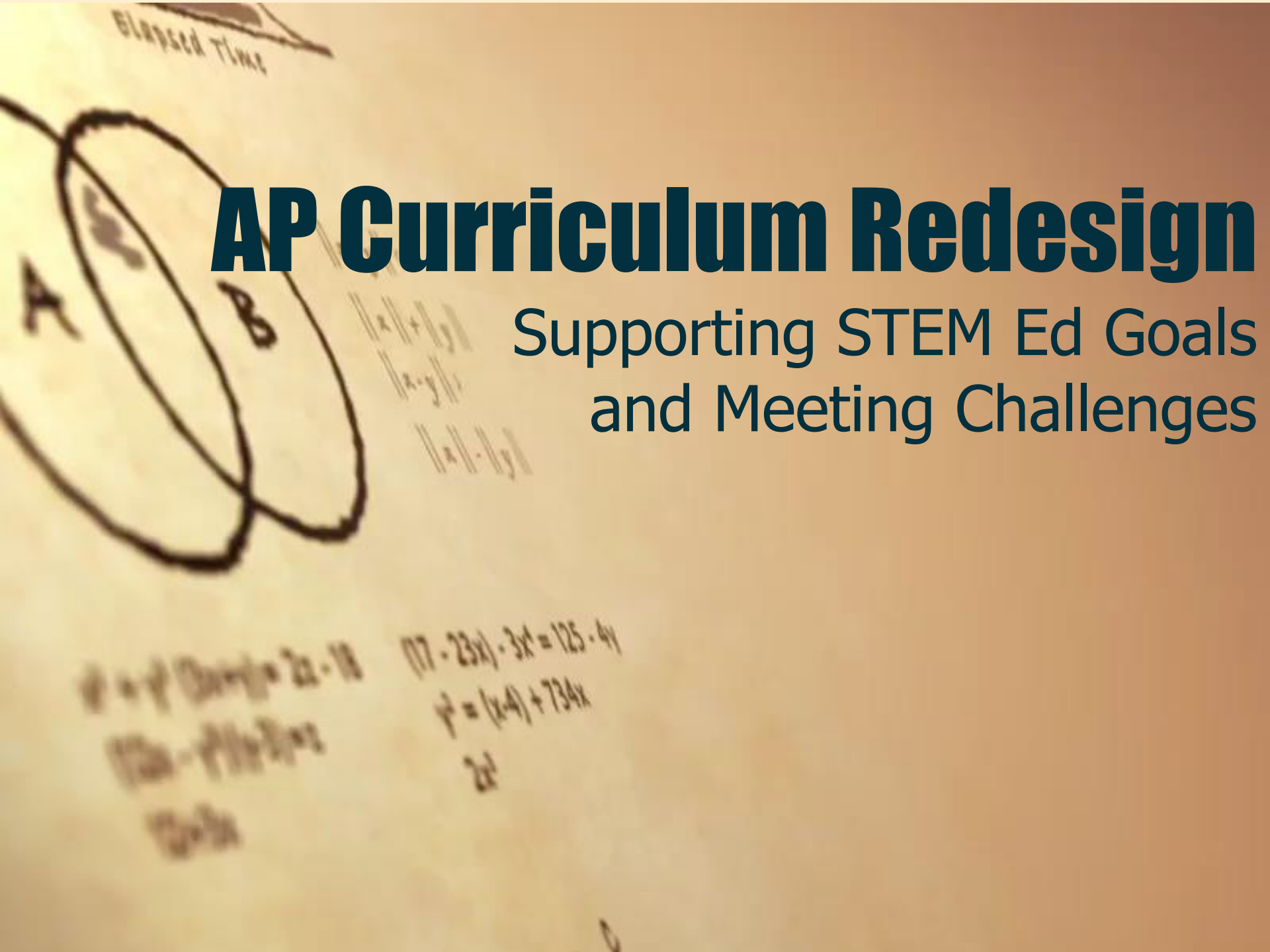
AP® CollegeBoard

# How Do We Maximize Output?




National Science Foundation
WHERE DISCOVERIES BEGIN

AP® CollegeBoard



# AP Curriculum Redesign

## Supporting STEM Ed Goals and Meeting Challenges

# AP Science Courses Now

AP is college level work

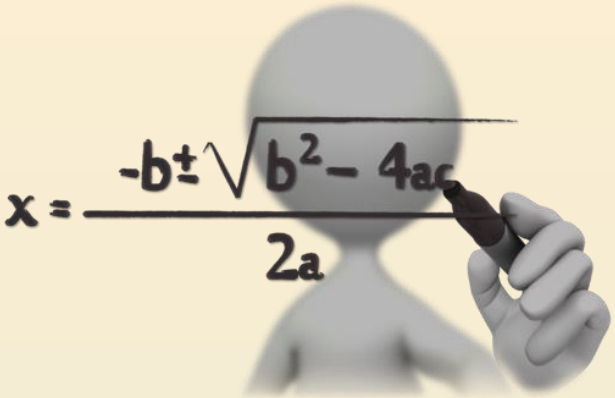
that fuels critical thinking

to inspire engaged students

National Science Foundation
WHERE DISCOVERIES BEGIN

AP® CollegeBoard

# Impetus for AP Science Redesign



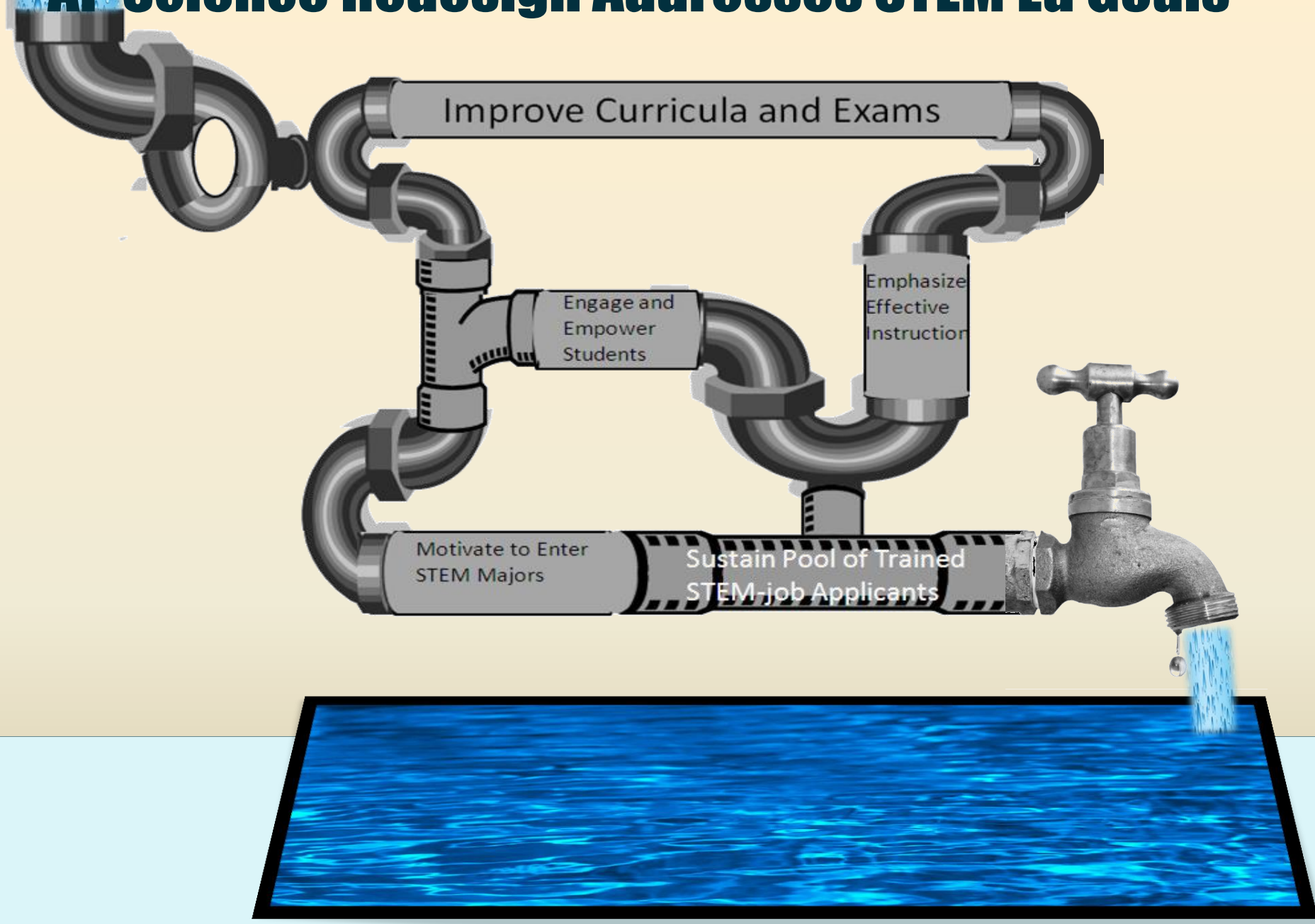

We need to emphasize conceptual over algorithmic understanding

We need to develop information producers and critical information consumers

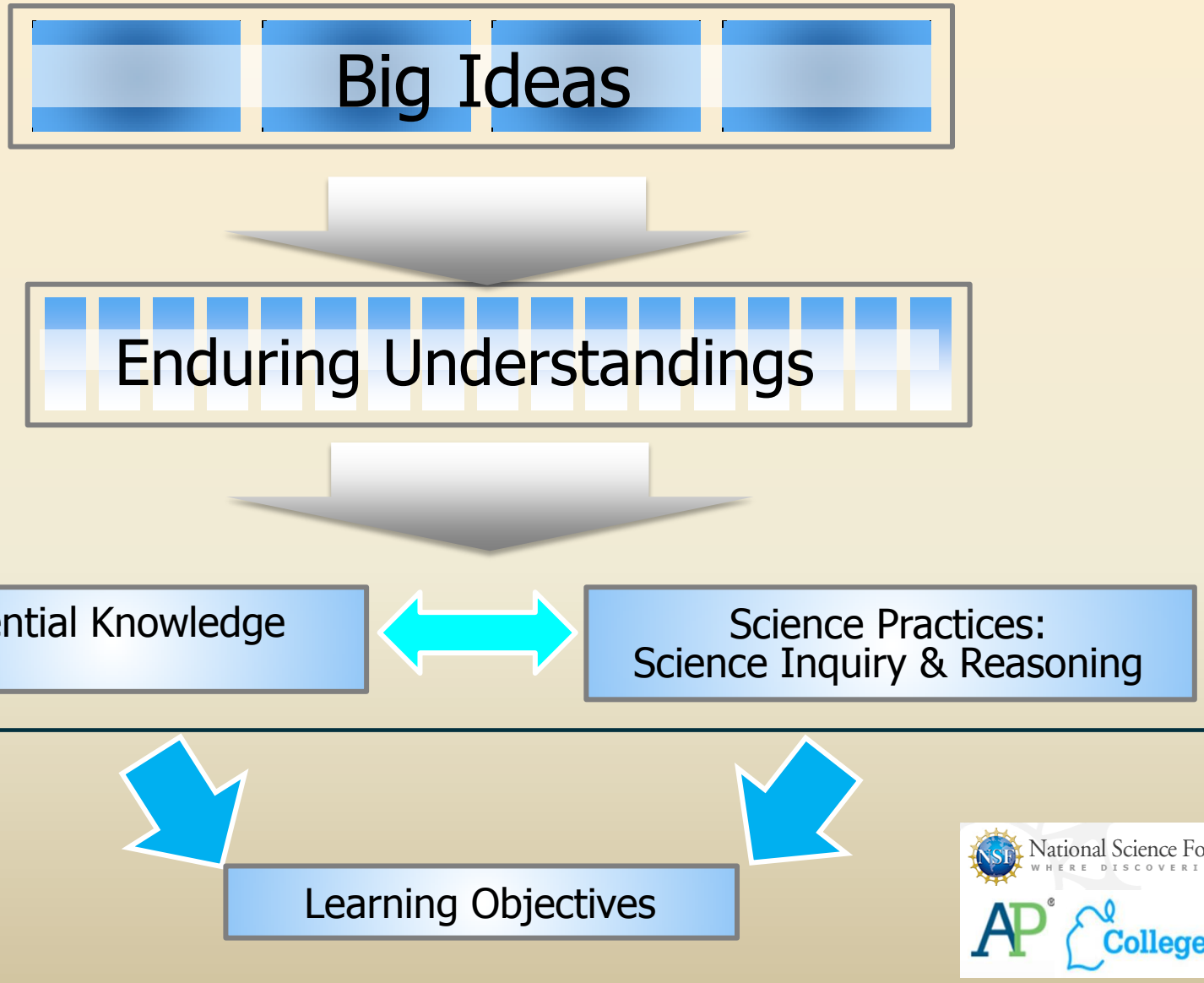
National Science Foundation
WHERE DISCOVERIES BEGIN

AP CollegeBoard

# AP Science Redesign Addresses STEM Ed Goals



# Structure of the AP® Science Curriculum Framework

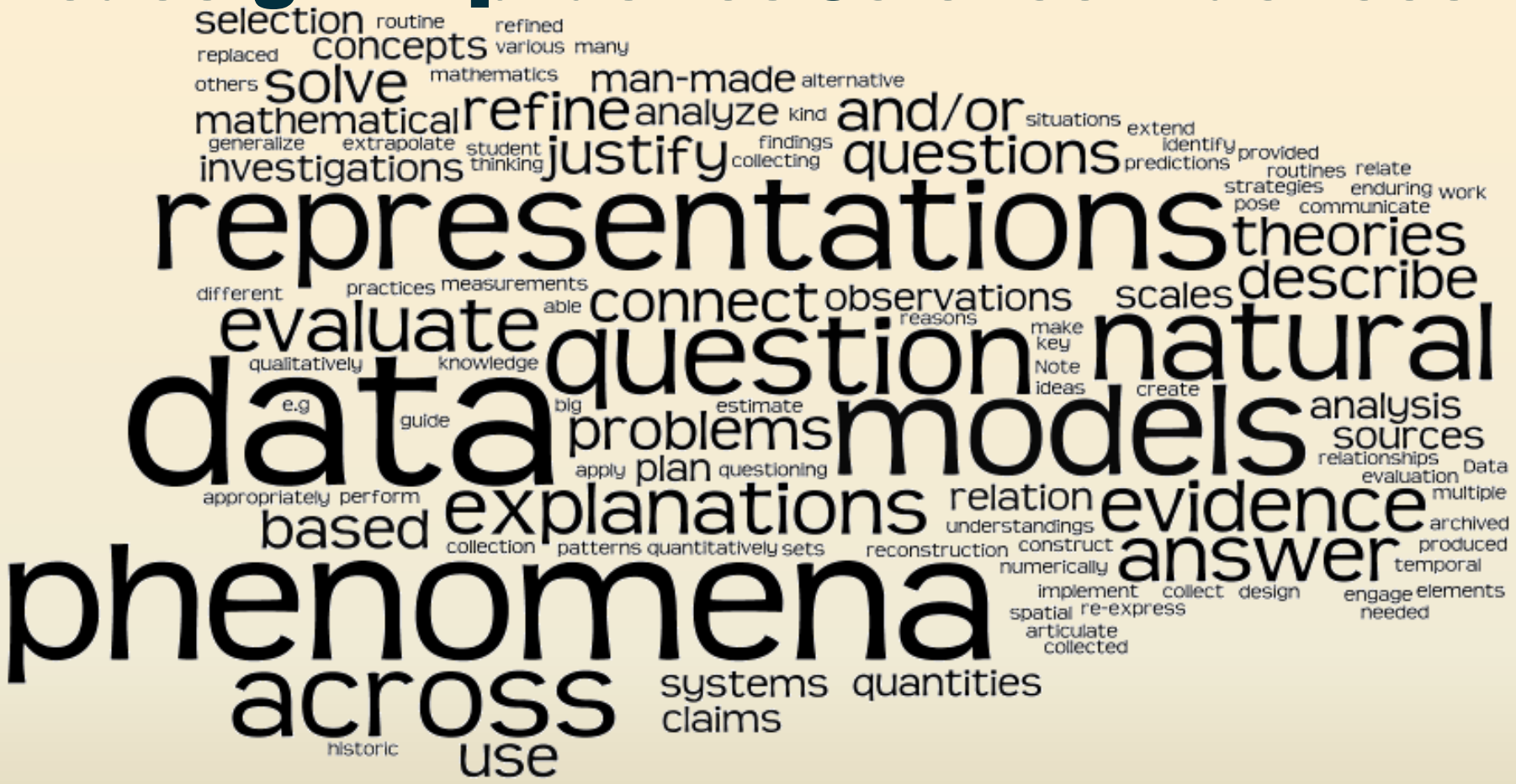



National Science Foundation
WHERE DISCOVERIES BEGIN
AP
CollegeBoard

# Clear learning objectives provide a window for what content and science practices will be assessed.

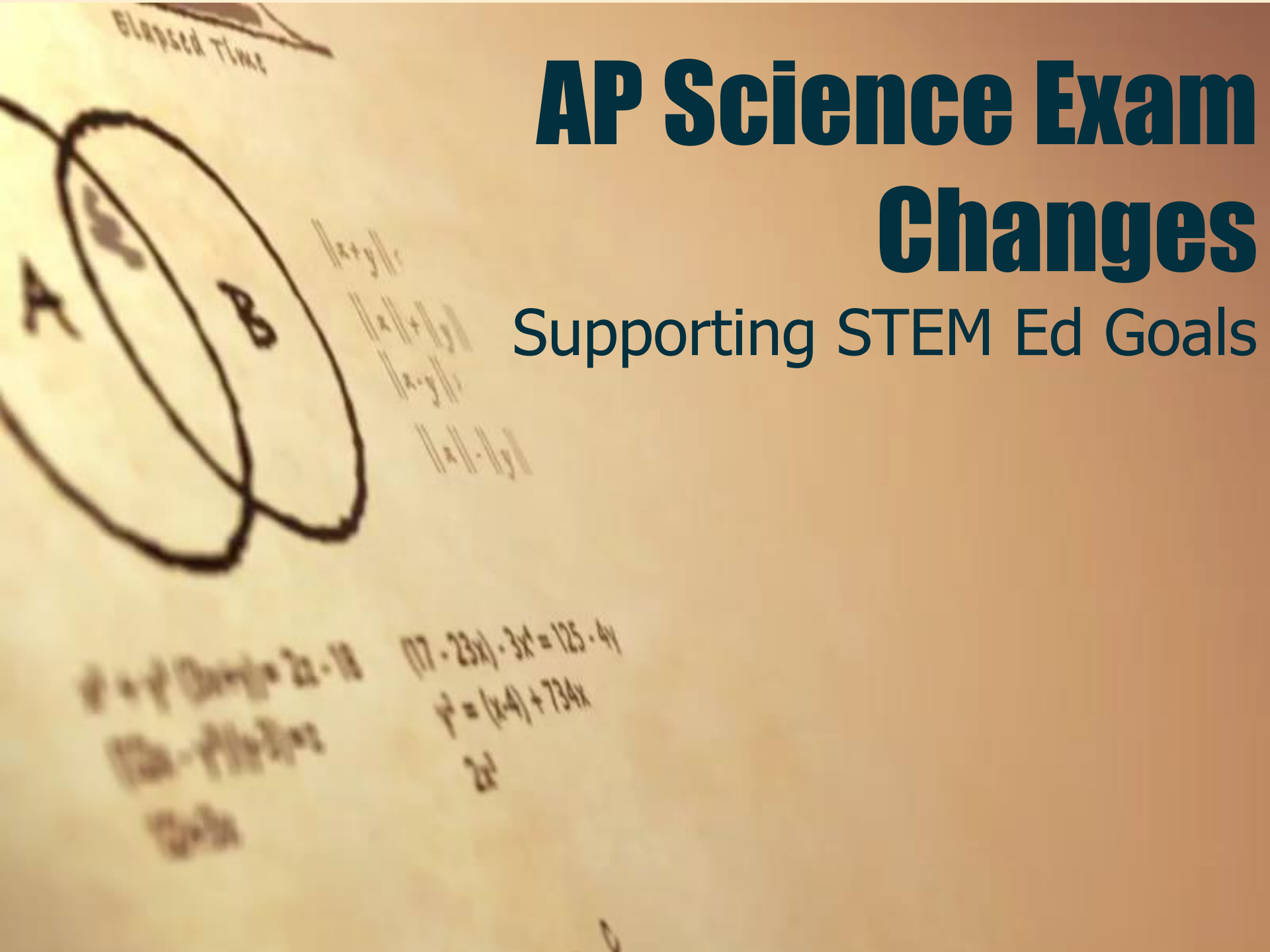
| | |
|---|---|
| **Content** | **Essential Knowledge 3.C.3**<br>Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells. |
| **+** | |
| **Skill** | **Science Practice 5.1**<br>The student can analyze data to identify patterns or relationships. |
| **Learning Objective** | **Learning Objective (3.C.3 & 5.1)**<br>The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. |

# Redesign Emphasizes Science Practices




National Science Foundation
WHERE DISCOVERIES BEGIN

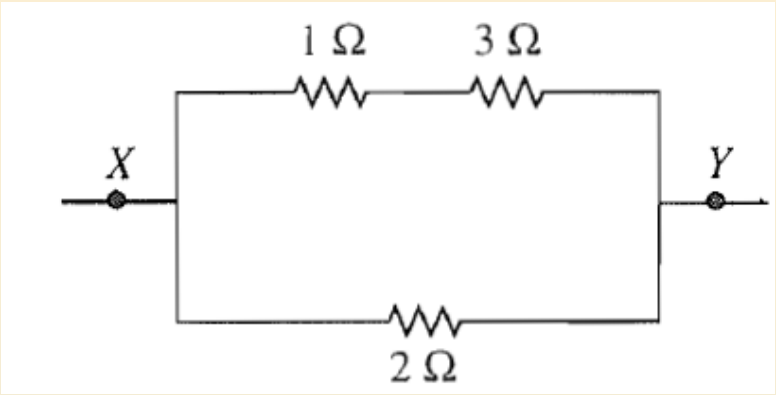
AP CollegeBoard



# AP Science Exam Changes

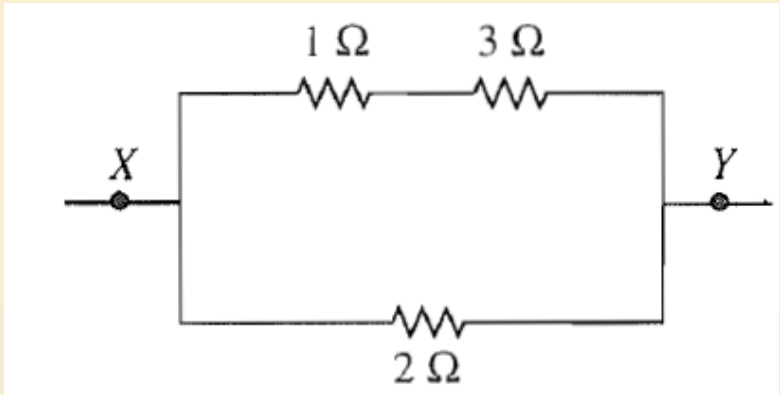
## Supporting STEM Ed Goals

# Which of these items is old vs. new? What's different about them?




Rank the currents through the three resistors.

(a) $I_1 > I_2 > I_3$
(b) $I_2 > I_1 > I_3$
(c) $I_2 > I_1 = I_3$
(d) $I_1 = I_2 = I_3$




The electric resistance of the part of the circuit between X and Y is

(a) 1.3 Ω
(b) 2.0 Ω
(c) 4.0 Ω
(d) 6.0 Ω

# New item type in Physics: Multiple correct

**Multi–Correct: Students will need to select all the correct answers to the question below in order to earn credit.**

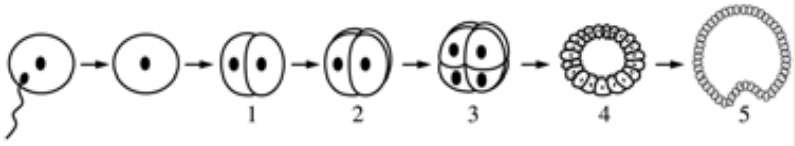
A race car going around a flat, unbanked circular track gradually increases speed as it completes one full trip around the track. Which of the following can explain why the car gains speed?

(A) Energy stored in the fuel is converted to mechanical energy.
(B) A component of the frictional force exerted by the ground on the tires is directed toward the center of the circle.
(C) A component of the frictional force exerted by the ground on the tires is in the direction of motion.
(D) The car's velocity and acceleration are perpendicular.

http://media.collegeboard.com/digitalServices/pdf/ap/2012advances/12b_6714_AP_Physics_WEB_121001.pdf

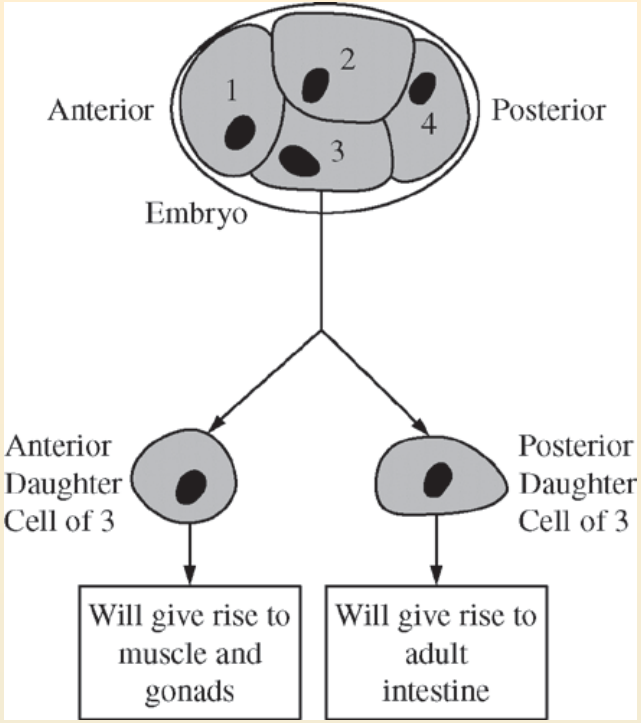
National Science Foundation
AP CollegeBoard

# Which of these items is old vs. new? What's different about them?




The picture above represents some stages in the early development of an embryo. In which of the stages does gastrulation begin?

A. 1
B. 2
C. 3
D. 4
**E. 5**

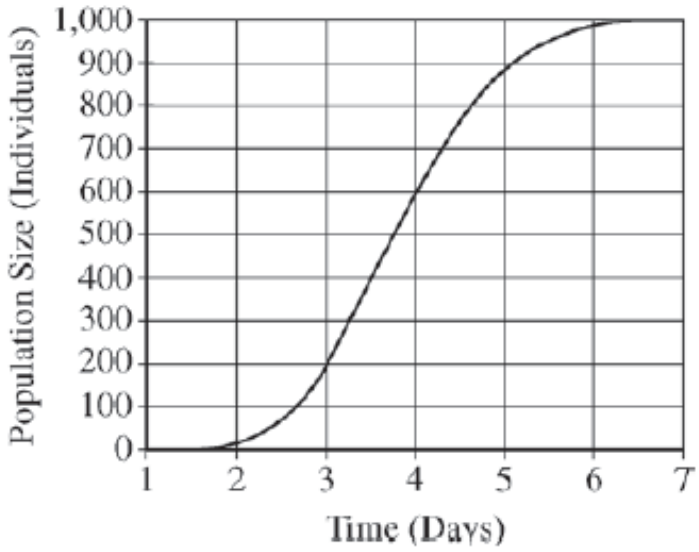



The diagram above shows a developing worm embryo at the four-cell stage. Experiments have shown that when cell 3 divides, the anterior daughter cell gives rise to muscle and gonads and the posterior daughter cell gives rise to the intestine. However, if the cells of the embryo are separated from one another early during the four-cell stage, no intestine will form. Other experiments have shown that if cell 3 and cell 4 are recombined after the initial separation, the posterior daughter cell of cell 3 will once again give rise to normal intestine.

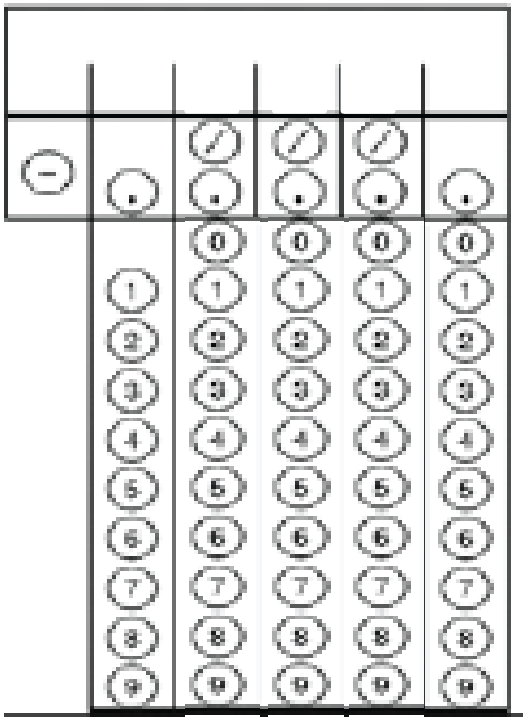
**Which of the following is the most plausible explanation for these findings?**

A) A cell surface protein on cell 4 signals cell 3 to induce formation of the worm's intestine.
B) The plasma membrane of cell 4 interacts with the plasma membrane of the posterior portion of cell 3, causing invaginations that become microvilli.
C) Cell 3 passes an electrical signal to cell 4, which induces differentiation in cell 4.
D) Cell 4 transfers genetic material to cell 3, which directs the development of intestinal cells.

# New item type in Biology: Grid Ins




1. Use the graph above to calculate the mean rate of population growth (individuals per day) between day 3 and day 5. Give your answer to the nearest whole number.



http://apcentral.collegeboard.com/apc/public/repository/AP_BiologyCED_Effective_Fall_2012_lkd.pdf

National Science Foundation

AP CollegeBoard

# Which of these items is old vs. new? What's different about them?

| | |
|---|---|
| $H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(l)$ | $\Delta H° = x$ |
| $2\ Na(s) + \frac{1}{2}O_2(g) \longrightarrow Na_2O(s)$ | $\Delta H° = y$ |
| $Na(s) + \frac{1}{2} O_2(g) + \frac{1}{2} H_2(g) \longrightarrow NaOH(s)$ | $\Delta H° = z$ |

Based on the information above, what is the standard enthalpy change for the following reaction?

$Na_2O(s) + H_2O(l) \longrightarrow 2\ NaOH(s)$

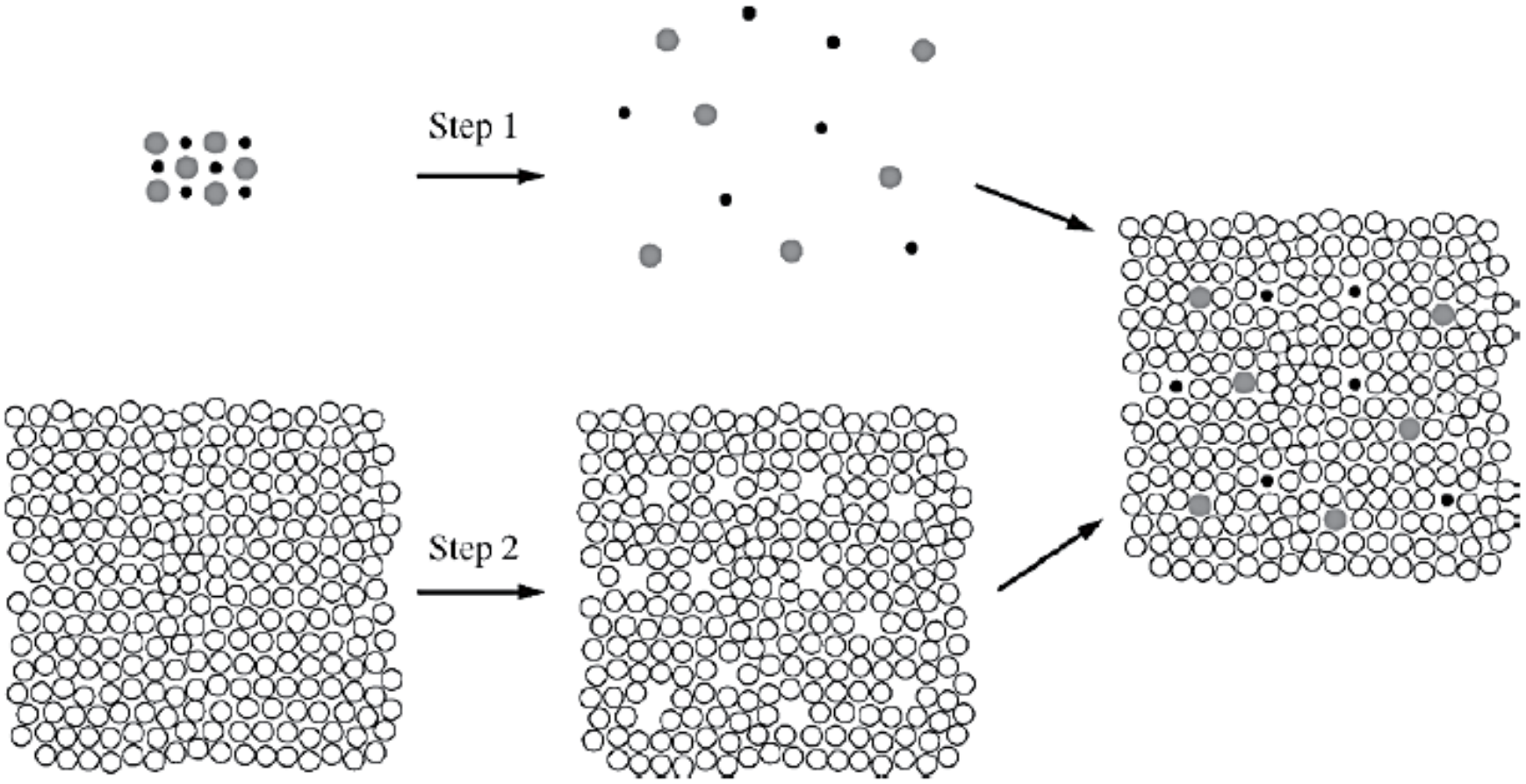
(A) x + y + z

(B) x + y - z

(C) x + y - 2z

(D) 2z - x - y

(E) z - x - y




27. The dissolution of an ionic solute in a polar solvent can be imagined as occurring in three steps, as shown in the figure above. In step 1, the separation between ions in the solute is greatly increased, just as will occur when the solute dissolves in the polar solvent. In step 2, the polar solvent is expanded to make spaces that the ions will occupy. In the last step, the ions are inserted into the spaces in the polar solvent. Which of the following best describes the enthalpy change, $\Delta H$, for each step?

(A) All three steps are exothermic.
(B) All three steps are endothermic.
(C) Steps 1 and 2 are exothermic, and the final step is endothermic.
(D) Steps 1 and 2 are endothermic, and the final step is exothermic.

# New item type in Chemistry: Item Sets

**Questions 34-38**

$$K(s) + \frac{1}{2}Cl_2(g) \rightarrow KCl(s) \qquad \Delta H^\circ = -437 \text{ kJ/mol}_{rxn}$$

The elements K and Cl react directly to form the compound KCl according to the equation above. Refer to the information above and the table below to answer the questions that follow.

| Process | $\Delta H^\circ$ ($kJ/mol_{rxn}$) |
|---|---|
| $K(s) \rightarrow K(g)$ | $v$ |
| $K(g) \rightarrow K^+(g) + e^-$ | $w$ |
| $Cl_2(g) \rightarrow 2\,Cl(g)$ | $x$ |
| $Cl(g) + e^- \rightarrow Cl^-(g)$ | $y$ |
| $K^+(g) + Cl^-(g) \rightarrow KCl(s)$ | $z$ |

34. How much heat is released or absorbed when 0.050 mol of $Cl_2(g)$ is formed from $KCl(s)$?

(A) 87.4 kJ is released
(B) 43.7 kJ is released
(C) 43.7 kJ is absorbed
(D) 87.4 kJ is absorbed

35. What remains in the reaction vessel after equal masses of $K(s)$ and $Cl_2(g)$ have reacted until either one or both of the reactants have been completely consumed?

(A) KCl only
(B) KCl and K only
(C) KCl and $Cl_2$ only
(D) KCl, K, and $Cl_2$

36. Which of the values of $\Delta H^\circ$ for a process in the table is (are) less than zero (i.e., indicate(s) an exothermic process) ?

(A) $z$ only
(B) $y$ and $z$ only
(C) $x$, $y$, and $z$ only
(D) $w$, $x$, $y$, and $z$

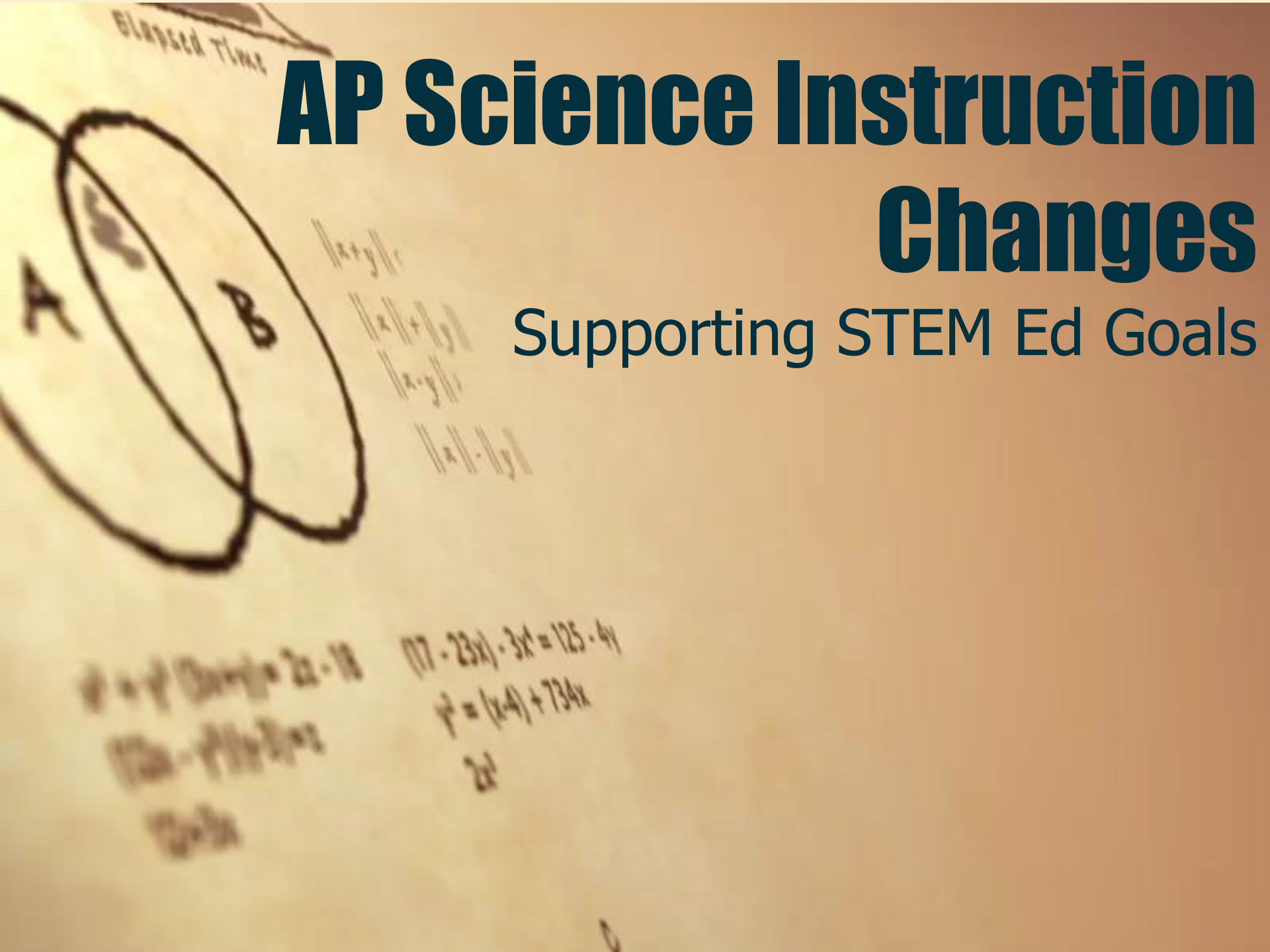
37. It is observed that the reaction producing KCl from its elements goes essentially to completion. Which of the following is a true statement about the thermodynamic favorability of the reaction?

(A) The reaction is favorable and driven by an enthalpy change only.
(B) The reaction is unfavorable and driven by an entropy change only.
(C) The reaction is favorable and driven by both enthalpy and entropy changes.
(D) The reaction is unfavorable due to both enthalpy and entropy changes.

$$Cl_2(g) + 2\,e^- \rightarrow 2\,Cl^-(g)$$

38. Which of the following expressions is equivalent to $\Delta H^\circ$ for the reaction represented above?

(A) $x + y$
(B) $x - y$
(C) $x + 2y$
(D) $\frac{x}{2} - y$

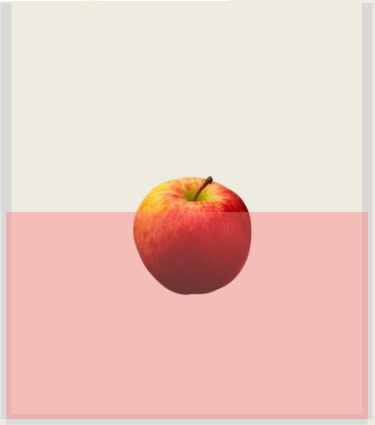


# AP Science Instruction Changes

## Supporting STEM Ed Goals

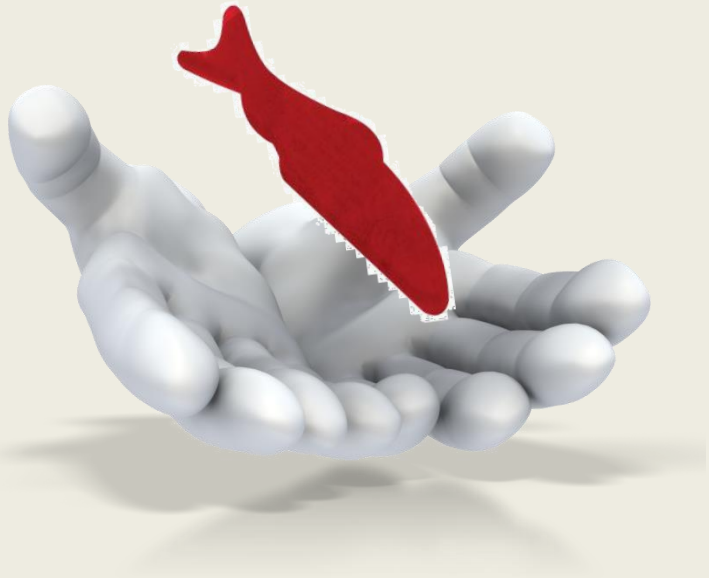
# Physics Activity

When a layer of oil covers water and an apple, will the apple be higher or lower than before?

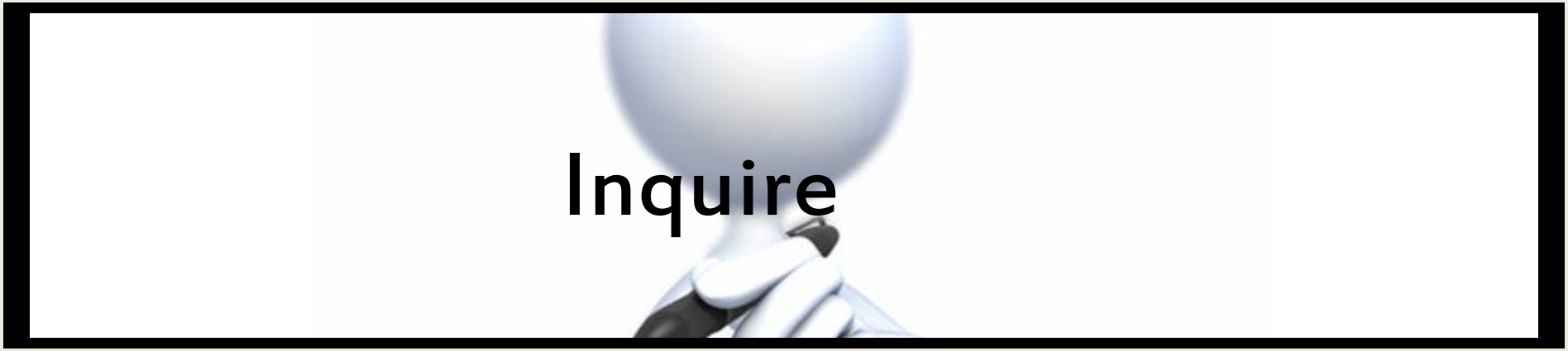


Inquire

# Chemistry Inquiry Activity



timer



# Alignment of STEM Ed Goals and the AP Science Redesign

AP course revisions aim to create a rigorous, research-based curriculum to:

- Emphasize deep understanding rather than comprehensive coverage
- Include a strong emphasis on inquiry and reasoning
- Prepare students for success in college-level courses by applying discipline-specific skills
- Stimulate and empower students to consider careers in those disciplines

National Science Foundation
WHERE DISCOVERIES BEGIN
AP® CollegeBoard


# More Information?

Serena Magrogan

Director, AP Science Curriculum and Content Development

smagrogan@collegeboard.org

National Science Foundation
WHERE DISCOVERIES BEGIN

AP® CollegeBoard